NASA Range Safety Program
2006 Annual Report

EMERGING TECHNOLOGY
AUTONOMOUS FLIGHT SAFETY SYSTEM – PHASE III

The autonomous flight safety system is a joint Kennedy Space Center and Wallops Flight Facility project currently in its third phase of development. The autonomous flight safety system is an independent and autonomous flight termination subsystem intended for expendable launch vehicles. It uses tracking and attitude data from an onboard GPS and inertial measurement unit sensors and configurable rule-based algorithms to make flight termination decisions.

The objectives of the autonomous flight safety system are as follows:

- Increase capabilities by allowing launches from locations that do not have existing range safety infrastructure
- Reduce costs by eliminating some downrange tracking and communications assets
- Increase safety by reducing the reaction time for flight termination decisions

Sounding Rocket Flight Test

The autonomous flight safety system flew on the Terrier Improved-Orion, two-stage sounding rocket shown at the right at White Sands Missile Range on April 5, 2006. A single-chassis, dual-processor, dual-GPS system was used.

The primary purpose of this flight was to demonstrate the key elements of the autonomous flight safety system concept of operations pertaining to pre-launch set-up (loading and verifying the application and configuration files), bench testing, vehicle integration, in-vehicle end-to-end testing, count-down system

verification procedures, and flight operations. A secondary purpose was to gather lessons learned which could be codified into the Autonomous Flight Safety System System Level Requirements document currently under revision.

The test incorporated redundant GPS sensors and used two independently programmed processors. One was loaded with a nominal trajectory and the other programmed with artificial rules under which the nominal flight would violate safety parameters and provoke termination commands. The autonomous flight safety system was not connected to actual explosives. The system functioned and reacted correctly during the entire flight from launch to parachute deployment.

SpaceX Falcon I Orbital Flight at Kwajalein Reagan Test Site

The autonomous flight safety system is scheduled to fly on the next SpaceX Falcon I launch in January 2007 from the Reagan Test Site at Kwajalein. The Falcon I, shown at right, is a two-stage, liquid oxygen and rocket grade kerosene powered launch vehicle designed to achieve substantial improvements in reliability and cost and to deliver 480 kilograms (1058 pounds) to an orbit of 200 kilometers at 28.5° inclination. The first stage is almost entirely reusable and returns via parachute to a water landing. Lift-off weight for the standard Falcon I is approximately 27,000 kilograms (60,000 pounds), length is about

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22 meters (70 feet) and diameter is 1.67 meters (5.5 feet).

The autonomous flight safety system will interface with the low cost TDRSS transmitter to demonstrate space-based range concepts. The low cost TDRSS transmitter will transmit autonomous flight safety system GPS metric tracking and flight termination data to NASA's Tracking Data and Relay Satellite System. The Tracking Data and Relay Satellite System will relay the autonomous flight safety system data to White Sands Missile Range where it can then be transmitted to Wallops Flight Facility, Kennedy Space Center, and Kwajalein for analysis.
The primary objectives for the autonomous flight safety system during this launch opportunity are:

- To test as many elements of the Autonomous Flight Safety System Concept of Operations as feasible within a true expendable launch vehicle integration and launch operations environment
- To gain expendable launch vehicle test, integration, countdown, and flight experience time on specific autonomous flight safety system hardware configuration, including the first flight test of the command logic switching and interlock circuit board
- To gain expendable launch vehicle test, integration, countdown, and flight experience time on specific autonomous flight safety system software configuration items, including the configurable flight algorithm mission rule constructs, cross-sensor qualification algorithms, staging event detection algorithms, and the command logic switching and interlock circuit board voting firmware

The autonomous flight safety system hardware will be part of the payload and will not be recovered.